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**Theoretical Studies of Resonance Enhanced Stimulated Raman Scattering  
(RESRS) of Frequency Doubled Alexandrite Laser Wavelength in Cesium  
Vapor**

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## Introduction

The third phase of research on this project will focus on the propagation and energy extraction of the pump and SERS beams in a variety of configurations including oscillator structures. In order to address these questions a numerical code capable of allowing for saturation and full transverse beam evolution is required. The proposal which is forthcoming, will describe this effort in detail. However, as we do not want to lose continuity on the research we have begun to solve this problem at this time.

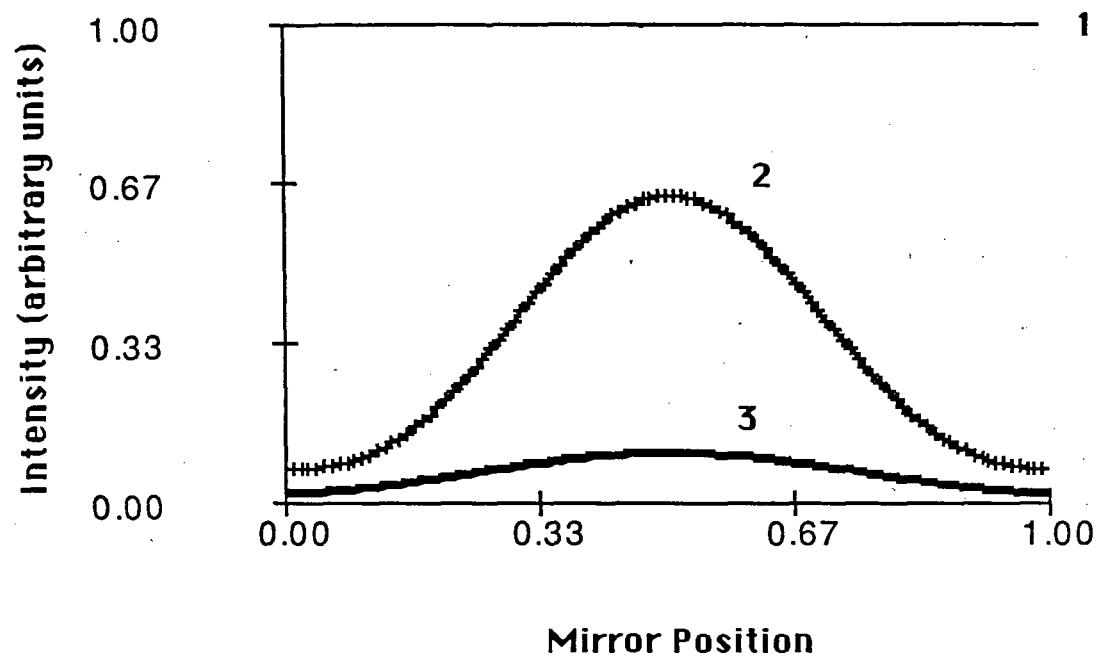
The method we propose is based on a discretized propagation energy extraction model which uses a Kirchhoff integral propagator coupled to the three level Raman model we have already developed. The model will have the resolution required by diffraction limits and will use the previous density matrix results in the adiabatic following limit. Owing to its large computational requirements, such a code must be implemented on a vector array processor such as the Cyber facility at the John von Neumann Center for Scientific Computing at Princeton University.

We have already begun testing one code on the Cyber by using previously understood two-level laser models as guidelines for interpreting the results. We have implemented two tests: 1) the evolution of modes in a passive resonator (Fox & Li), and 2) the evolution of a stable state of the adiabatically eliminated laser equations. These results which show mode shapes and diffraction losses for the first case and relaxation oscillations for the second one are shown in figures 1a and 1b, respectively. Finally, in order to clarify the computing methodology that we must use in order to exploit the Cyber's computational speed we have measured the time it takes to perform both of the computations previously mentioned to run on the Cyber and VAX 730. The laser

steady state problem required approximately 5 hours to run on the VAX and 30 seconds to run on the Cyber. This incredible time reduction along with the way in which our problem lends itself to parallel computation, we feel, will result in some very exciting results on the SERS problem as well as other problems in laser physics.

Attached is also a short description of our current "laser" model (CAVITY.FOR) and a flow chart (figures 2a - 2d) of the test computations.

**Spatial Mode Profile**  
F.N. = 2, No gain



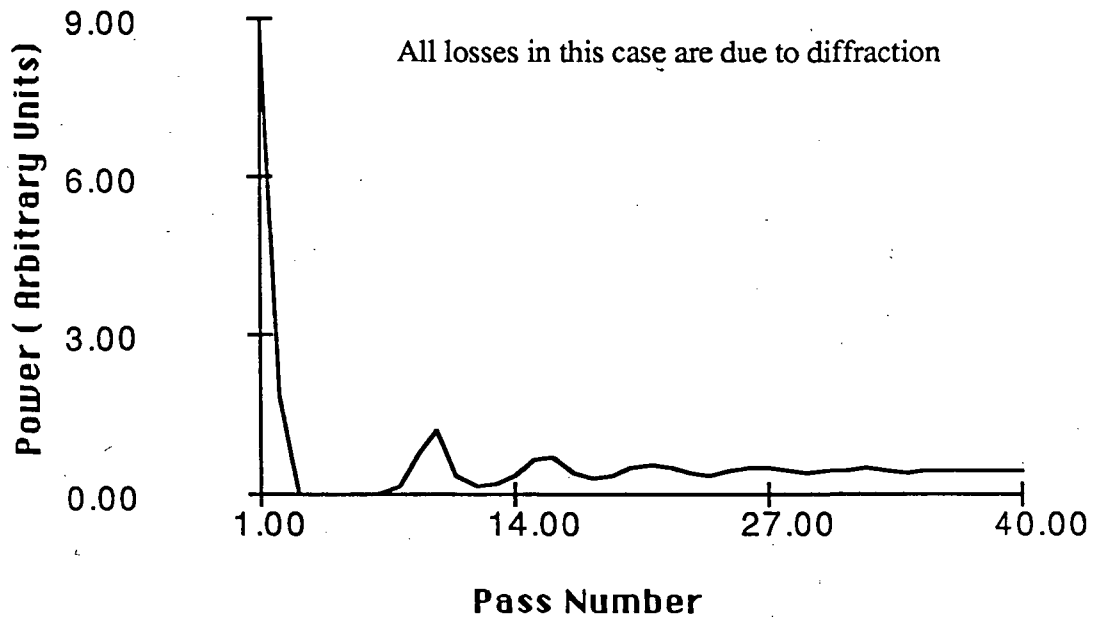
All losses in this case are due to diffraction

Fig. 1a

# Power vs. Pass Number

G = 2. Csi = 1. F.N. = 2

All losses in this case are due to diffraction



## Notes on CAVITY.FOR

CAVITY is a Fortran program running on the John Von Neumann Computing Center Cyber 205 Supercomputer. The program calculates the growth of modes in a Laser or Maser cavity by iterating Green function solutions for the electromagnetic fields from one mirror to the next, and then letting the fields interact with a "gain disk" at each mirror using 2 level rate equations.

There are several unusual features to this program, mostly stemming from the vector processing nature of the Cyber 205. In Cyber Fortran, arrays can be manipulated as objects using new data structures called "descriptors". To simplify the flowcharts descriptors and the arrays they reference have been identified. The routines that initialize variables and output data have also not been included for the sake of brevity.

In the formulation of the Green function problem the Fresnel number limit has been used. The Fresnel number becomes important where  $(a/b)^2$  is small<sup>1</sup>, and reduces the number of calculations for the integral. In the case where the mirrors are highly symmetric, the number of calculations can be reduced by a factor of  $M$ , where  $M$  is the number of gridpoints on the mirror (approx. 10000). This reduces what would normally be a " $M$ -squared" calculation to a calculation somewhere on the order of " $M$ " (with some uncertainty due to the strange way vectors are handled by the Cyber).

Times for running programs on the Cyber are on the order of 30 sec. per iteration, using 100x100 grids. The number of points that must be used for the problem is proportional to the Fresnel number. The IBM PC AT, by comparison, took several hours per iteration for 40X40 grids. Times for both these machines can be improved by efficient algorithm design, but by doing so one loses much of the clarity of the original program.

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<sup>1</sup>Fox, A.G., and Li,T., "Resonant Modes in a Maser Interferometer", Bell Syst. Tech. Jou., Vol. 40(1961)

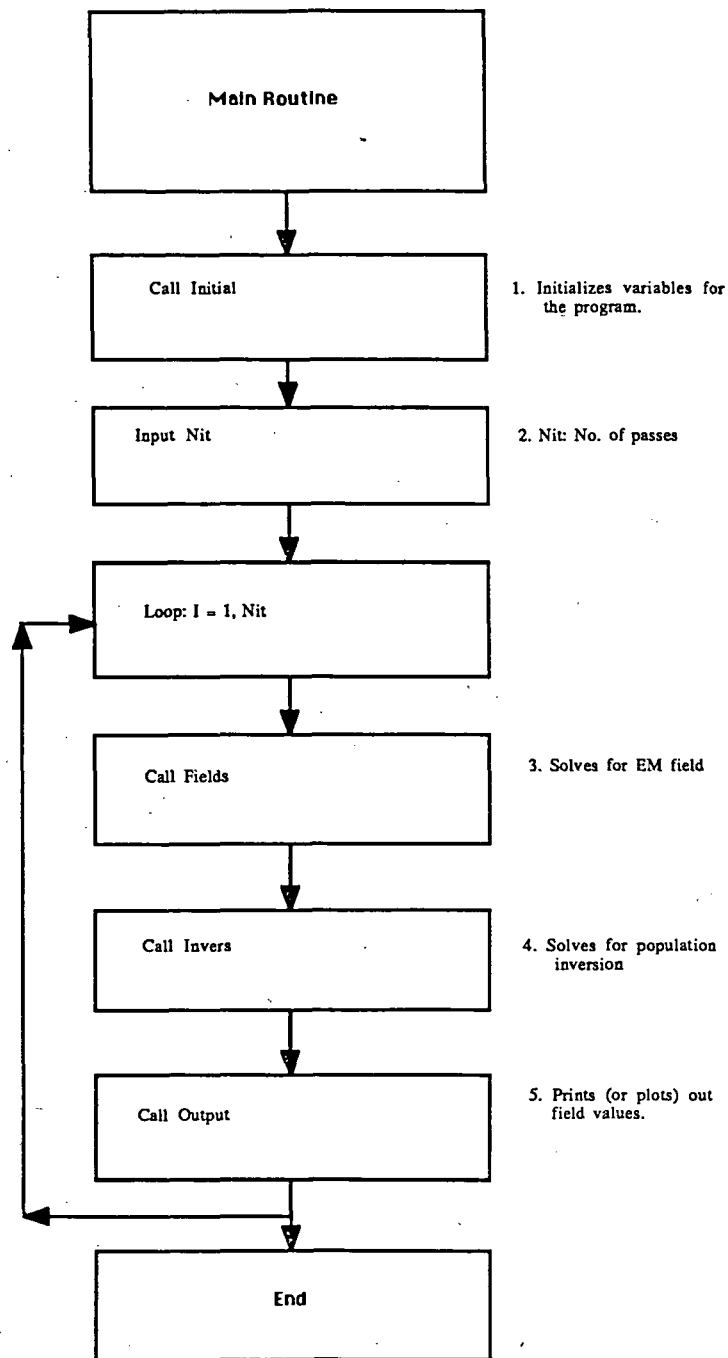


Fig. 2a

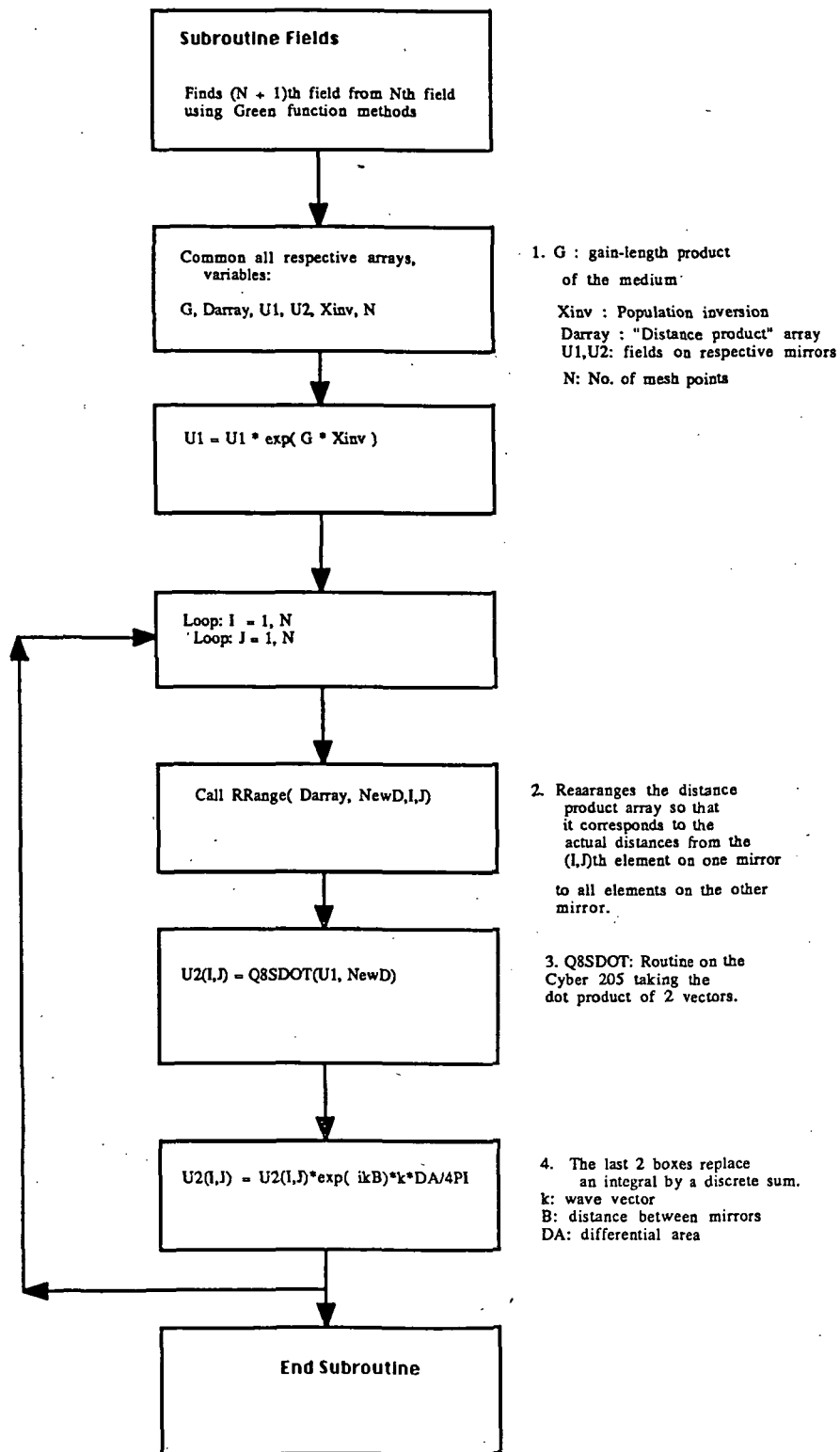


Fig. 2b



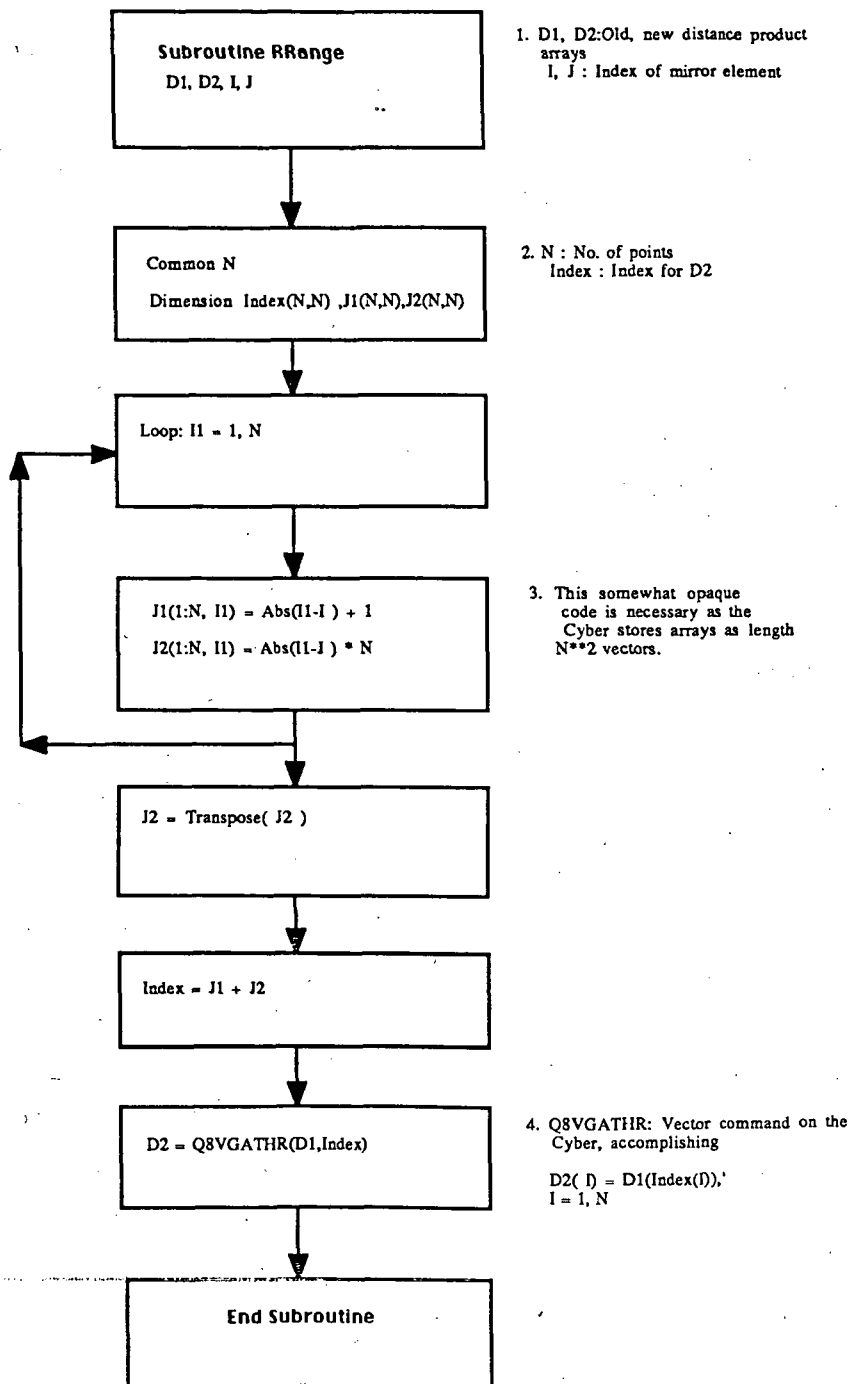


Fig. 2C

